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#3

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Signed Andrew Craig

Dated 14 MAR 2000

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The Patent Office

Request for grant of a patent

(See the notes on the back of this form. You can also get an explanatory leaflet from the Patent Office to help you fill in this form)

The Patent Office

Cardiff Road
Newport
Gwent NP9 1RH

1. Your reference — SMC/LF/P4258

2. Patent application number *(The Patent Office will fill in this part)* — **9904946.2**

3. Full name, address and postcode of the or of each applicant *(underline all surnames)*

   Kenneth **O'Hara**
   Pen-yr-allt Farm House
   Lake Road
   Padeswood
   Mold Flintshire CH7 4H7

   Patents ADP number *(if you know it)*

   If the applicant is a corporate body, give the country/state of its incorporation — UK

   7G5446CC1

4. Title of the invention — Gas Distribution System

5. Name of your agent *(if you have one)* — ROYSTONS

   "Address for service" in the United Kingdom to which all correspondence should be sent *(including the postcode)*

   Tower Building
   Water Street
   Liverpool
   L3 1BA

   Patents ADP number *(if you know it)* — 1438001

6. If you are declaring priority from one or more earlier patent applications, give the country and the date of filing of the or of each of these earlier applications and *(if you know it)* the or each application number

Country	Priority application number *(if you know it)*	Date of filing *(day / month / year)*

7. If this application is divided or otherwise derived from an earlier UK application, give the number and the filing date of the earlier application

Number of earlier application	Date of filing *(day / month / year)*

8. Is a statement of inventorship and of right to grant of a patent required in support of this request? *(Answer 'Yes' if:*

   a) any applicant named in part 3 is not an inventor, or
   b) there is an inventor who is not named as an applicant, or
   c) any named applicant is a corporate body.
   See note (d))

   No

Patents Form 1/77

9. Enter the number of sheets for any of the following items you are filing with this form. Do not count copies of the same document

Continuation sheets of this form	
Description	6
Claim(s)	-
Abstract	-
Drawing(s)	1 + 1

10. If you are also filing any of the following, state how many against each item.

Priority documents	-
Translations of priority documents	-
Statement of inventorship and right to grant of a patent *(Patents Form 7/77)*	-
Request for preliminary examination and search *(Patents Form 9/77)*	-
Request for substantive examination *(Patents Form 10/77)*	-
Any other documents *(please specify)*	-

11. I/We request the grant of a patent on the basis of this application.

Signature [signature] Date 04.03.99

ROYSTONS - AUTHORISED AGENTS

12. Name and daytime telephone number of person to contact in the United Kingdom

S M Cardwell - 0151 236 1417/5147

Warning

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Notes

a) If you need help to fill in this form or you have any questions, please contact the Patent Office on 0645 500505.

b) Write your answers in capital letters using black ink or you may type them.

c) If there is not enough space for all the relevant details on any part of this form, please continue on a separate sheet of paper and write "see continuation sheet" in the relevant part(s). Any continuation sheet should be attached to this form.

d) If you have answered 'Yes' Patents Form 7/77 will need to be filed.

e) Once you have filled in the form you must remember to sign and date it.

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Title: **Gas Distribution System**

The present invention relates to a method and apparatus for regulating the distribution of gaseous fluids.

There are many situations where submerged diffusers are used to introduce gas into a liquid. For example to transfer oxygen into a liquid (typically water) for the purposes of aeration and mixing, and especially to oxygenate the water. Such techniques are used in aerobic biological treatments systems as used to treat sewage, effluents of various types, and storm water and water in aquaria or lakes and rivers, among others. They are also used for air stripping of volatile organics from contaminated water.

It is common to treat foul sewage in "active slurry treatment plants" by feeding precise volumes of air to a plurality of diffusers which release the air into the water in precise small bubbles to stimulate natural processes. The number of diffusers and hence the spacing is calculated relative to the volume of water to be treated and the amount of treatment required. The diffusers are usually placed at the lowest point in the water column allowing the most time for air to pass through the water prior to reaching the atmosphere.

In the known systems a plurality of diffusers are fed from a supply line, usually from a suitable air source such as an air pump, which delivers a constant and even supply of air. The diffusers are disposed in series along the supply line and the quantity of air emerging from each diffuser is intended to be substantially the same. In the known sewage treatment systems potential pressure drop along the line from one diffuser to the next is rendered negligible by utilising a supply pipe having a large cross-sectional area and a relatively low-pressure supply. The cross-section of the pipe has to be calculated having regard to the number of diffusers and the discharge rate in order to ensure that

there is a negligible pressure drop along the length of the pipe and thereby ensure that the flow from the diffusers is balanced. In other specific aeration systems a manually adjustable valve may be provided for each diffuser to balance their output. The known system of individually balanced gas diffusers is difficult to set up to ensure correct balance, usually requiring accurate levelling of the outlet diffusers.

A constant flow regulator and a method of manufacturing same comprising a moving "O" ring is described in Patent Nos. EP 115342 and GB 2136713. The described regulator gives a constant through volume flow rate of liquid over a wide range of supply pressures. A regulator of this type can be designed to produce a specific flow rate over a prescribed pressure range and can be moulded from plastics which makes them extremely economical to produce. When a plurality of such constant flow devices are fitted in series in a pipeline supplied with liquid at a sufficiently high pressure, the flow rate is constant from each regulated line irrespective of the pressure fluctuations along the pipeline(s) of the system. The supply line pressure has to be above a pre-determined minimum level at the point where the pressure drop is highest. Usually this will be at the end of the pipeline. The use of these devices has not been considered to regulate the flow of gases. There is no teaching to use these devices with fluids other than liquids. The reason for this may be that none of the commercially available devices operate to produce constant flow with fluctuating air pressure.

It is an aim of the present invention to provide a gas distribution system which overcomes the current difficulties.

One aspect of the invention provides a method of distributing gas through a piped system having a plurality of outlet lines branching from a common supply line or manifold, the method comprising continuously generating a predetermined minimum volume of gas and introducing it into the pipe system, delivering a desired quantity of gas

at each of the outlets by providing a constant flow regulator means in each outlet line which limits the flow to a set amount when the pressure in the pipe system exceeds a predetermined minimum value.

More particularly the predetermined minimum volume of gas exceeds a calculated minimum volume which is required to be delivered by the diffusers. Preferably the method comprises using a moving "O" ring constant flow regulator. In one embodiment substantially the same quantity of gas is delivered at each outlet irrespective of pressure drop along the pipe, at least within a flow range which is deemed acceptable. For most applications an accurate and even quantity of gas is delivered at each outlet. This can be achieved using constant flow regulators having a specific and even flow rating for each outlet.

Another aspect of the present invention provides a gas distribution system comprising a gas distribution supply line, a source of gas pressure connected to the distribution supply line, and a plurality of outlet lines branching from the distribution supply line, and characterised by a constant flow regulator disposed between the distribution supply line and each outlet line to cause a desired flow of gas to be delivered through the outlet lines.

More particularly a predetermined minimum volume of gas is supplied, which volume is calculated to exceed the minimum volume which is to be delivered from the diffusers. The desired flow of gas is a desired even flow of gas.

A preferred constant flow regulator comprises a moving "O" ring constant flow regulator. The preferred moving "O" ring regulator is chosen which is precisely tuned to deliver the desired calculated supply of gas required at the outlet line irrespective of changes in supply pressure such that it is self compensating for changes in supply pressure within its designed operating range.

In an alternative, a moving "O" ring regulator is used that only allows a desired maximum flow (volume) of gas to pass through above a known pressure of gas. Using such a regulator, pressure drops along the pipeline can be compensated for by using a regulator which has the desired maximum flow at a lower pressure to reflect the pressure drop. By this means a substantially even flow of gas is achieved from all the outlets. It will be understood that when the term even is used, there will most usually be an acceptable tolerance variation to the desired flow rate.

Each outlet line has a suitable outlet nozzle. They may be aeration nozzles, diffusers or any other suitable nozzle for the intended application. In a preferred application each outlet line supplies a respective diffuser. Conveniently the outlet lines are disposed in series along the distribution supply line. The number of outlet lines and hence outlet nozzles/diffusers are calculated and spaced according to the particular application. Preferably the gas originates from a suitable source, usually generated by a pump, and preferably it delivers a constant volume of gas. The system can be used for distributing any desired gas composition. For many applications the gas will be air. The distribution supply line comprises at least one length of pipe. As an alternative it may comprise a plurality of lengths of pipe branching from a common manifold or having a direct connection with the supply of gas. The pipeline may include a return line or be of ring main type. The outlet lines may incorporate a backflow regulation device and/or an isolation ball valve. Such devices may incorporate the aforesaid constant flow regulator or be provided as separate devices. The constant flow regulator, any backflow regulation device and any isolation valve may be combined with an outlet diffuser.

The invention can be used for a large number of potential applications, for example the treatment sewage, leachate and agricultural waste water by the introduction of air, air stripping of volatile compounds from water or other solutes, mixing water

columns, aerating and mixing of aquaria, ponds, lakes and rivers or tanks containing fish, and in connection with various industrial processes and even for the control of power tools. Where the system is used for the purpose of introducing gas into a liquid or other gas, the backflow prevention device avoids the liquid or gas entering the system should the system enter a state of relative negative pressure. The isolation ball valve allows individual branches to be isolated.

For any given application the delivery rate from the outlet lines will be known and the source of gas will be capable of maintaining a constant supply of no less than the calculated minimum requirement for the system.

The present invention may be used for any of the above mentioned applications and any other applications in which gas is to be transferred to a liquid.

The present invention will now be described further hereinafter, by way of example only, with reference to the accompanying drawings; in which: -

Figure 1 shows schematically one embodiment of air distribution system according to the present invention, and

Figure 2 is a graph of flow rate against pressure for a preferred pressure regulator.

For convenience the present invention is described by way of example in relation to the treatment of water by the injection of air. In one application for waste treatment the water will contain effluent. The water/effluent to be treated is shown at 1 and held within an open well or receiver 3. An air distribution pipeline 2 extends from a source of air 1 which supplies the air under pressure to the pipeline. A motor driven pump (not illustrated) conveniently serves this purpose. The pipeline 2 has a plurality of outlets 4 disposed along the length thereof at spaced intervals. For the purpose of effluent treatment each outlet is provided with a diffuser which releases the air into the water/effluent in the form of small bubbles. In order to ensure that the flow of air from

each diffuser is the same, a regulator 5 is incorporated into the flow line between the pipework 2 and the outlet diffuser 4. The regulator may be part of the diffuser or a separate component. The regulator is designed to deliver a constant flow irrespective of pressure variations in the pipeline when the pressure in the pipeline exceeds a predetermined minimum value, which minimum value is calculated to be that which will ensure that each regulator supplies the desired volume of gas. The preferred regulator device is of a type known as a moving "O" ring constant flow regulator such as described in the above mentioned patents. These are very economical to produce, especially when moulded from plastics.

The preferred moving "O" ring regulator is designed to operate to deliver a desired flow of air over a range of supply pressures. That is to say it is self-compensating for changes in supply pressure over a prescribed range of pressures above a minimum pressure level. Figure 2 is a graph of a constant pressure regulator of moving "O" ring type having characteristics of the described type and shows flow volume against pressure. It shows how the flow rate plateaus after pressure P1. Using a plurality of flow regulators in a distribution supply line will give rise to an even delivery of air from the plurality of diffusers providing the pressure in the pipeline exceeds the minimum threshold value P1.

In an alternative, the regulator only allows a set maximum flow (volume) of air to pass through at a given pressure of air providing the pressure in the system exceeds that given pressure then the flow rate from each outlet line will be at the set maximum flow rate and a regulator is chosen which provides the desired flow rate for a particular application.

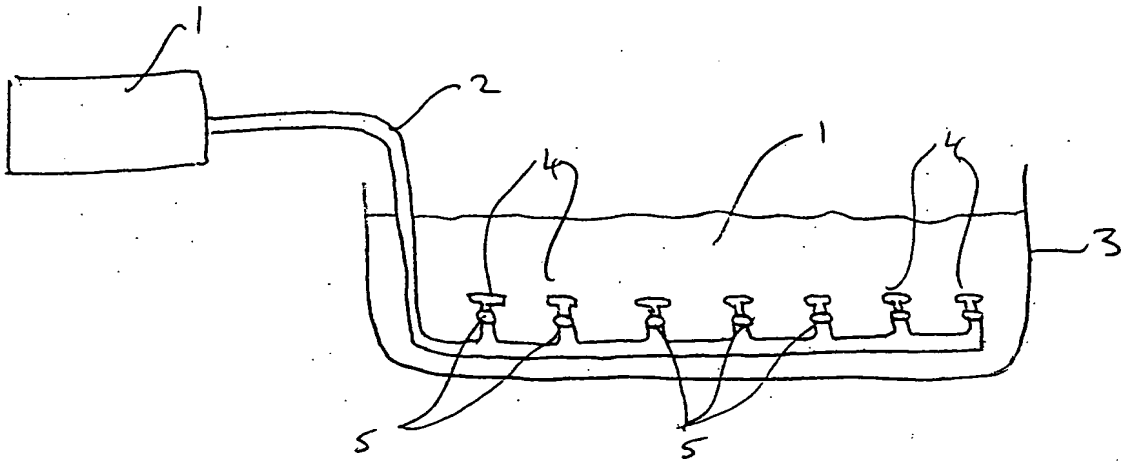

Fig 1

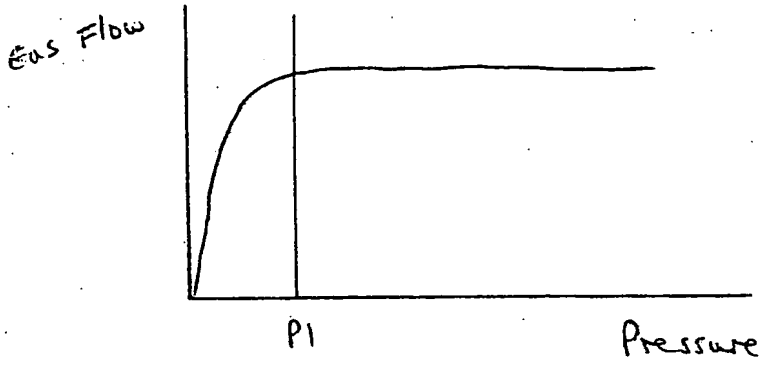

Fig 2

PG CB0[redacted]0721

Raystem

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